§8. Impurity Measurements for Edge Transport Barrier Discharges in the Compact Helical System

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The formation of an edge transport barrier (ETB) has recently been found in the Compact Helical System (CHS) plasmas heated by neutral beam injection (NBI) with strong gas puffing.[1] In order to study impurity behaviors in the ETB discharges, we have measured the radiation profiles and the vacuum ultraviolet (VUV) spectra by using an absolute extreme ultraviolet (AXUV) photodiode array and a grazing incidence spectrometer. The experimental setup of the photodiode array and the spectrometer have already been reported elsewhere.[2),3)] The lines of sights of these diagnostics are arranged within a horizontally elongated cross section. The total radiation power from the plasma is routinely monitored by a single channel pyroelectric detector. The temporal and spectral resolution of the spectrometer is about 10 ms and 0.3 nm, respectively.[3]

The time traces of the various signals in a typical ETB discharge are shown in Fig. 1. The magnetic axis position and the toroidally averaged ellipticity in this case are R_{ax}=92.1 cm (in major radius) and κ=1.22, respectively. A spontaneous transition to the ETB phase occurred at 70 ms with an abrupt drop of H_α intensity. The Thomson scattering diagnostics shows that the electron density steeply increases only near the edge, while the the electron temperature is almost unchanged at the transition. The signals of all the channels of the AXUV photodiode array also increase more steeply at the transition as shown in Fig. 1 (c) for the center (ch6) and edge (ch3) viewing chords. The radiation profile rapidly changes into more hollow one immediately after the spontaneous transition to the ETB phase. This observation indicates that the radiation power tends to increase especially near the edge just after the transition.

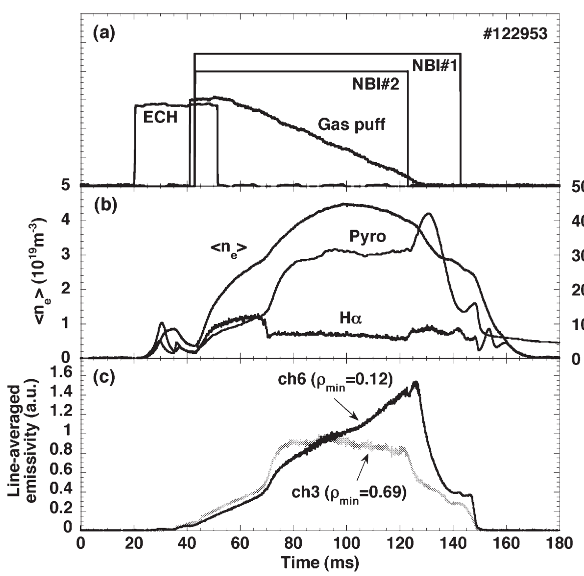

Fig. 1. Time traces of the parameters for a typical ETB discharge. Line averaged emissivity measured by the AXUV photodiode array is shown in (c) for the two lines of sights.

Several resonance lines of metallic (iron, chrome, titanium) and oxygen impurities are identified from the VUV spectra in the ETB discharges. The temporal evolutions of the intensities of several representative lines in an ETB discharge are plotted in Fig. 2 at 10 ms intervals. The transition occurred at 73 ms in this discharge, and the signals are normalized to those just before the transition (at 65 ms). The line intensities of all impurities increase more steeply just after the transition in the same way as the radiation emissivity. Judging from the ionization potentials for these ions, three metallic impurity lines appear to represent mainly the radiation from the core region. Since the electron density and temperature in the core does not change at the transition, the metallic impurity ion densities actually seem to increase inside the transport barrier. Though changes in metallic impurity transport coefficients inside the ETB are inferred from the VUV spectra, numerical simulations of impurity transport are required for the quantitative analyses.

References

1) Okamura, S. et al.: Plasma Phys. Control. Fusion **46** (2004) A113.

2) Suzuki, C., Peterson, B. J., Ida, K: Rev. Sci. Instrum. **75** (2004) 4142.

3) Suzuki, C. et al.: J. Plasma Fusion Res. SERIES **7**, 74 (2006)

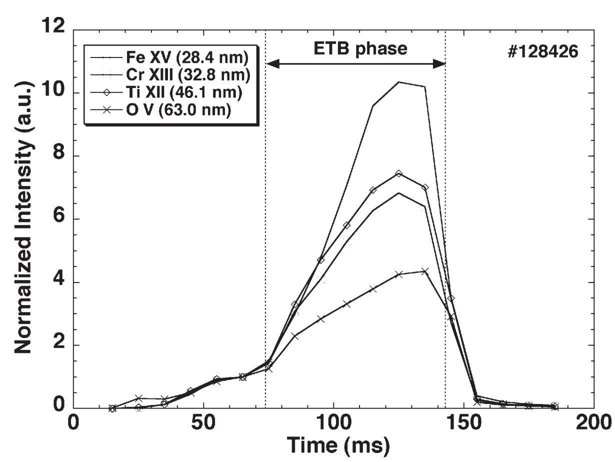

Fig. 2. Temporal evolutions of several representative impurity line intensities in an ETB discharge.